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A NEW MYXOSPORIDIAN PARASITE, THE CAUSE OF "WORMY" HALIBUT

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APPENDIX VIII TO THE REPORT OF THE U. S. COMMISSIONER OF FISHERIES FOR 1923

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A NEW MYXOSPORIDIAN PARASITE, THE CAUSE OF "WORMY" HALIBUT.[1]

By H. S. Davis, *Fish Pathologist, U. S. Bureau of Fisheries.*

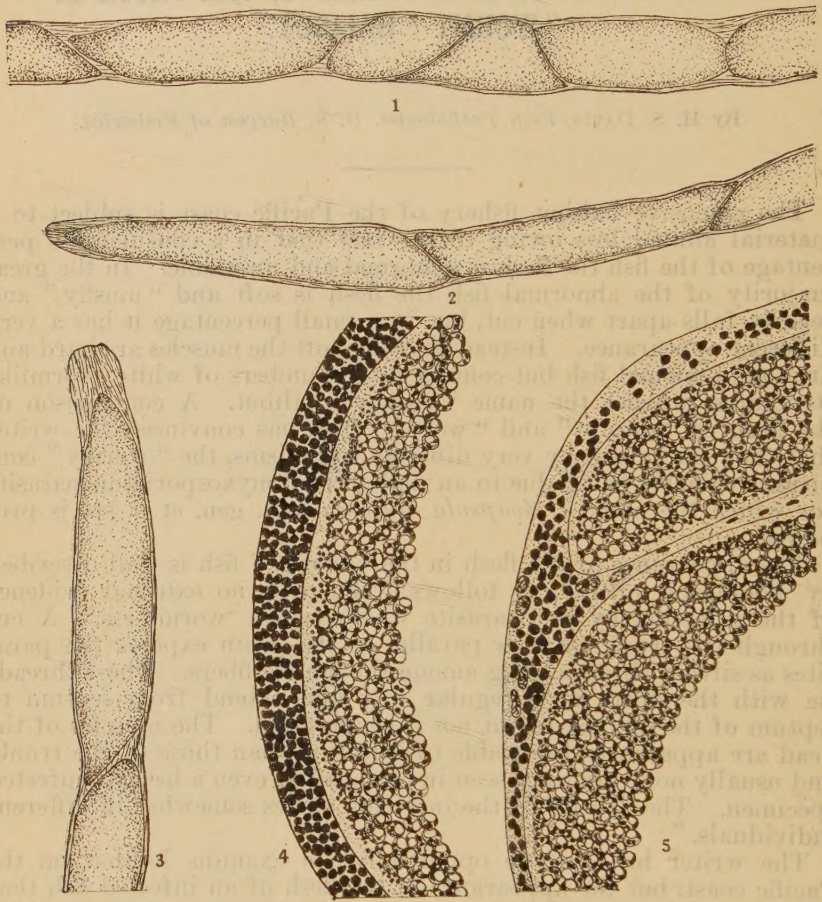
The extensive halibut fishery of the Pacific coast is subject to a material annual loss owing to the fact that in a considerable percentage of the fish the flesh is abnormal and unsalable. In the great majority of the abnormal fish the flesh is soft and "mushy" and readily falls apart when cut, but in a small percentage it has a very different appearance. Instead of being soft the muscles are hard and firm as in normal fish but contain large numbers of white, wormlike structures, whence the name "wormy" halibut. A comparison of the flesh of "mushy" and "wormy" fish has convinced the writer that they are caused by very different organisms, the "wormy" condition evidently being due to an undescribed myxosporidian parasite for which the name *Unicapsula muscularis* n. gen. et n. sp. is proposed.

The appearance of the flesh in the "wormy" fish is well described by Thompson (1916), as follows: "There is no external evidence of the infection by the parasite which causes 'worminess.' A cut through the trunk muscles parallel to the grain exposes the parasites as silvery threads lying among the muscle fibers. These threads lie with the fibers in a regular way and extend from septum to septum of the myomeres but not through them. The muscles of the head are apparently less liable to infection than those of the trunk, and usually none are to be seen in the head of even a heavily infected specimen. The density of the infection varies somewhat in different individuals."

The writer has had no opportunity to examine halibut on the Pacific coast, but the appearance of the flesh of an infected fish that was sent to Washington in cold storage agreed in every respect with Thompson's description. In this fish the white opaque "worms" were very common and presented a sharp contrast to the smaller translucent fibers that made up the great bulk of the muscles. A closer examination confirmed Thompson's observation that the "worms" are simply hypertrophied muscle fibers filled with a whitish granular mass. This granular material, which is composed of the spores of a myxosporidian, is surrounded by a relatively thin, transparent envelope made up of muscle fibrils embedded in sarcoplasm and surrounded by the sarcolemma. The diameter of the infected fibers in material preserved in formalin was about 0.6 to 0.8

[1] Appendix VIII to the Report of the U. S. Commissioner of Fisheries for 1923. B. F. Doc. 957.

mm., while that of the uninfected fibers was about 0.2 to 0.4 mm. These measurements are somewhat greater than those given by Thompson. Possibly the discrepancy may be due to a difference in the size of the fish, that examined by the writer having a total length of about 5 feet.



FIGS. 1, 2, AND 3.—Portion of muscle fibers showing the arrangement of the parasites within the fibers. ×20.

FIG. 4.—Cross section of a small portion of an infected muscle fiber. The cut ends of the fibrils are shaded black. Within the fibrillar layer can be seen a portion of the trophozoite surrounded by a distinct ectoplasmic layer. ×575.

FIG. 5.—Cross section of a portion of an infected fiber showing the overlapping ends of two trophozoites. This is a somewhat later stage than Figure 4, and the fibrils are beginning to degenerate. ×575.

When examined under the microscope, the infected fibers were seen to contain a number of elongated trophozoites arranged in a single row within the fiber but usually overlapping more or less at the ends (figs. 1 to 3). In every case the parasites extended practically the entire length of the fiber. This condition was also noticed by Thompson, who suspected they were trophozoites of a sporozoan but was unable to definitely determine their nature.

It is a remarkable fact that the trophozoites never extend to the sarcolemma, there being always a thin layer of sarcoplasm and muscle fibrils between the two. This is well shown in Figures 4 to 6, where the peripheral layer of fibrils and sarcoplasm can be distinctly seen. As shown in the figures the trophozoites vary considerably in size, some being several times the length of others. The length of those measured varied from 2 to 6 mm. The size of the mature trophozoite appears to be dependent on the number present in a fiber, since the diameter of the fibers containing fully developed trophozoites is remarkably uniform. There may be as many as six trophozoites, or possibly even more, in a fiber. In all cases observed by the writer they were arranged in a single row extending from one end of the fiber to the other, but in Thompson's figures several trophozoites are shown lying side by side.

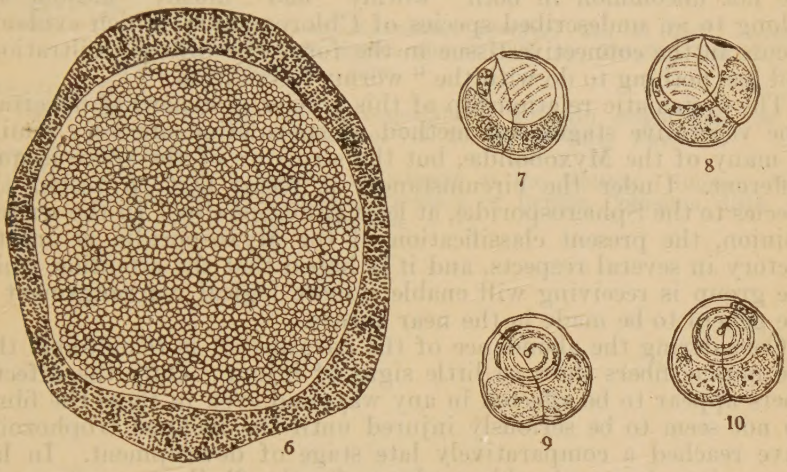


FIG. 6.—Cross section of an infected fiber showing the trophozoite filled with spores and surrounded on all sides by a portion of the muscle fiber. ×190.
FIGS. 7 AND 8.—Spores viewed from the side. ×2,500.
FIGS. 9 AND 10.—Polar views of spores. ×2,500.

Only sporulating trophozoites were found in the fish examined by the writer, the spores forming the whitish, granular mass previously referred to. Surrounding the spores is a thin but distinct layer of ectoplasm (figs. 4 and 5). Just within the ectoplasm can be seen numerous free nuclei and pansporoblasts in different stages of development. Evidently, as in many other myxosporidia that form cysts in the tissues, the development of the spores takes place in a comparatively narrow zone just within the ectoplasm.

The spores (figs. 7 to 10) are subspherical, asymmetrical, and contain but one capsule. The shell is thin and the sutural line indistinct. There is usually a slight indentation along the sutural line on the postcapsular side. The shell valves are very unequal in size, that containing the capsule being much larger than the other, which is evidently degenerate. The capsule is relatively large and appears spherical in shape except when viewed from the side, when a short neck can be distinguished connecting it with the shell (figs. 7 and 8).

The coiled filament is indistinct but can usually be made out by careful focusing. The nucleus of the capsulogenous cell can often be distinguished attached to one side of the capsule. The sporoplasm is finely granular and fills practically all of the spore not occupied by the capsule. Two nuclei are present, and the sporoplasm is often more or less distinctly divided into two parts of approximately the same size, each containing a nucleus. There is no evidence of the presence of an iodophile vacuole. The diameter of the spore is about 6μ, that of the capsule 3μ.

The spore was seen and figured by Thompson (1916). His Figure 8 is evidently that of a mature spore, the large eosinophile body being the capsule. Thompson also found a spore shaped like a "four-pointed star with four polar capsules," which he thought might have some relation to the "wormy" condition of the flesh. These spores are not uncommon in both "wormy" and "mushy" halibut and belong to an undescribed species of Chloromyxum, which evidently occurs in the connective tissue in the form of "diffuse infiltration" and has nothing to do with the "wormy" condition.

The systematic relationship of this species is somewhat uncertain. The vegetative stages and method of sporulation are very similar to many of the Myxobolidæ, but the structure of the spore is quite different. Under the circumstances it seems best to assign this species to the Sphærosporidæ, at least provisionally. In the writer's opinion, the present classification of the Myxosporidia is unsatisfactory in several respects, and it is hoped that the attention which the group is receiving will enable a more logical rearrangement of the genera to be made in the near future.

Considering the abundance of the parasites, it is remarkable that the muscle fibers show so little signs of injury. Only the infected fibers appear to be affected in any way, and even in these the fibrils do not seem to be seriously injured until the inclosed trophozoites have reached a comparatively late stage of development. In late stages there is a noticeable tendency for the fibrils to swell up and undergo a hyaline degeneration (fig. 5), but no fibers have been observed in which the fibrils were entirely destroyed. According to Thélohan (1895) and Keysselitz (1908), a somewhat similar hyaline degeneration is produced by *Myxobolus pfeifferi* in the muscles of the barbel.

Since the spores are formed only within the muscle fibers and apparently remain there indefinitely, it is obvious that they can only be released by the death or injury of the host. From our knowledge of the life cycle of other Myxosporidia we may assume that the spores are taken into the digestive tract of the halibut with the food and germinate in the intestine. The minute amœboid sporoplasm then makes its way into the blood vessels and is carried to the muscles, where it leaves the capillaries and enters the muscle fibers. The large number of infected fibers indicates that, in all probability, there is a multiplicative stage before the young trophozoites enter the fibers. After entering the fibers the trophozoites evidently divide several times, for in no other way can we explain the presence of several trophozoites in each fiber.

It is interesting to note that although a number of Myxosporidia are known to occur in the muscles of various species of fish the great

majority is found only in the connective tissues. Only a very few species ever enter the muscle fibers, and even in these forms the principal seat of infection is the connective tissues. The present species appears, therefore, to be unique among the Myxosporidia, since so far as known it develops only within the muscle fibers and never in the surrounding connective tissues. In this respect it resembles the Sarcosporidia and lends additional interest to Darling's theory that these muscle parasites are simply aberrant Cnidosporidia.

For convenience a brief description of the genus Unicapsula nov. gen. is appended:

Spores rounded; asymmetrical, without processes of any kind, only one large rounded capsule present; valve of shell containing capsule much larger than the other; tissue parasites, polysporous.

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